**Protocol MS1**

*1. Sampling procedures*

The selection of the transect zones was based on lithology and altitude, with each zone containing contrasting bedrocks and wide ranges of altitude, as well as land use, grazing intensity, slope position and slope angle. Within the units the sample locations were selected at random. Lithology was classified into the classes of calcareous bedrocks (limestone and marl with thin shale intercalations) and acid bedrocks (granite, ignimbrite and quartzite). Land use was classified into 5 categories: grassland, cultivation, abandoned cultivation, cultivated grassland and forest. Grazing intensity was estimated in the field and was ranked into 4 levels: none, low, medium and high. The criteria to rank grazing intensity were based on the presence of physical indications of grazing, plant density, as well as the replacement of tall native tussock grasses (e.g. *Carex sp*.) with shorter invasive grass species and matted herbs including *Rumex sp*.. Slope position was classified into 3 groups: top, slope and valley bottom. Furthermore, slope angle and altitude were measured and recorded as numeric variables.

We took one complete soil profile per sampling point and divided these into sections of 10 cm, starting from the top until the C or R horizon was reached. Soil depth was defined from the ground level to the top of the C or R horizon and measured below the ground level. Undisturbed samples were collected from the representative layers with Kopecky rings (100 cm-3) in order to determine bulk density using the core method. Afterwards, all samples were weighted and transferred into sealed plastic bags before transportation.

*2. Laboratory analysis*

Soil bulk density was measured by weighing the intact ring samples after oven-drying at 105°C, and calculated with the volume of 100cm3. Field moisture contents were measured by weighing ring samples before and after oven-drying. pH values were measured using a glass electrode with H2O (w/v=1:5) following the standard protocol of Bates (1973). Total carbon, nitrogen and inorganic carbon contents were measured with a VarioEL Elementar analyzer (Elementar, Germany) with an extension for inorganic carbon. Total organic carbon concentrations were calculated by subtracting inorganic carbon concentrations from total carbon concentrations.

Total SOC stocks were calculated by adding SOC stocks every 10 cm of the soil profile from the surface down to the C horizon using the equation:

$$SOC stock=\sum\_{i=1}^{i=k}B\_{i}C\_{i}D\_{i}$$

In which, Bi= bulk density (g cm-3) of the layer i, Ci=C content (%) of the layer i; Di= the thickness (cm) of layer i. Total SOC stocks and bulk densities were not corrected for gravel contents and gravel was negligible in most of the soil profiles.

*3. Statistics*

Linear models were used to test the effect of the soil formation and environmental (SFE) factors (lithology, land use, grazing intensity, slope position, altitude and slope angle) on total SOC stocks and SOC stocks of the upper 10cm. We consider the soil properties (soil depth, moisture and pH) as potential conditional variables, because they may be important predictors for SOC stocks, although the SFE factors rather than soil properties are the focus of our study. The conditional variables were selected from soil properties, based on the criteria that the variables should be significantly related to SOC stocks and also be independent of the SFE factors. The criterion of independence aimed to avoid difficulties in interpretation that are introduced by interactions between the conditional variables and the SFE factors. The linear models were applied to identify the conditional variables (soil properties) that are linearly related to the SOC stocks and independent from the SFE factors. When the conditional variables were selected, we applied the linear models with all conditional variables and only one additional SFE factor to predict SOC stocks. These models are aimed at investigating the effects of individual SFE factors and to make comparisons with the linear models without conditional variables.

For each of the models that appeared as a suitable model (Based on AIC and significance of coefficients), a thorough visual check of the assumptions underlying the linear model was conducted (normality, homoscedasticity, independence of errors and absence of structural deviations from each of predictors and the response variable) and any apparent violations were reported with the other model results. Analyses were performed with SPSS 22.0 (SPSS Inc., USA).